21. Zoological Results of the Third Tanganyika Expedition, conducted by Dr. W. A. Cunnington, 1904–1905. —Report on the Branchiura. By William A. Cunnington, M.A., Ph.D., F.Z.S.

[Received February 11, 1913: Read March 4, 1913.]

(Plates XLI.–XLV.*)

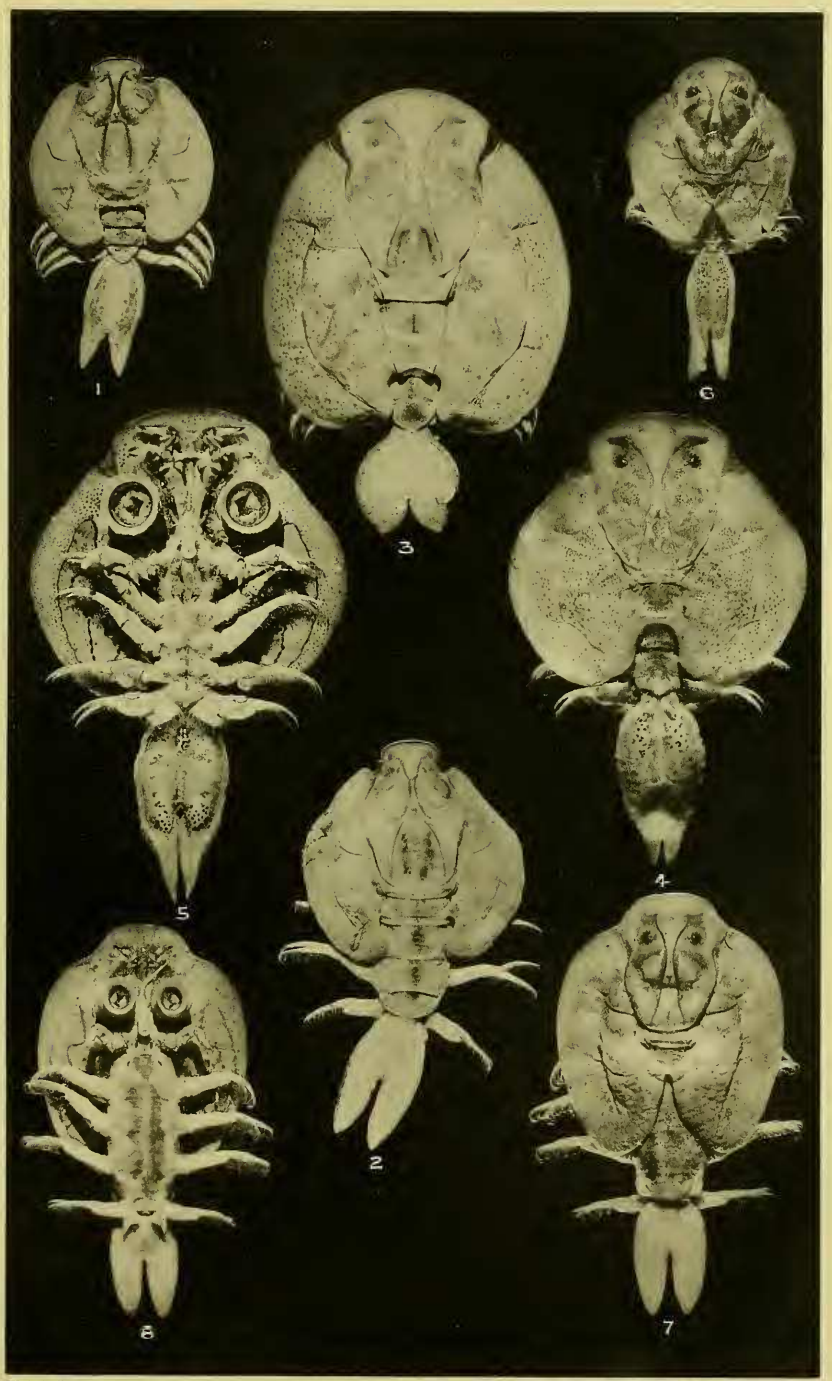
Index.

1. *Introduction.*

Through the collections made by Stuhlmann in Lakes Victoria Nyanza and Albert Edward Nyanza, and by Fülleborn in Lake Nyasa, we have for some time known of the existence of Argulidæ in the waters of those lakes. The material collected during the Third Tanganyika Expedition proves that these parasitic copepods also occur commonly in Tanganyika, from which lake, indeed, far more species are now known than from any of the other great African lakes. As many as 363 specimens were obtained by this Expedition, the great majority of them from Tanganyika, with a few from Victoria Nyanza. There are nine species represented in all, and it is interesting to remark that, while two species—both previously described—were found in Victoria Nyanza, the same two forms were associated with no fewer than seven new species in Tanganyika.

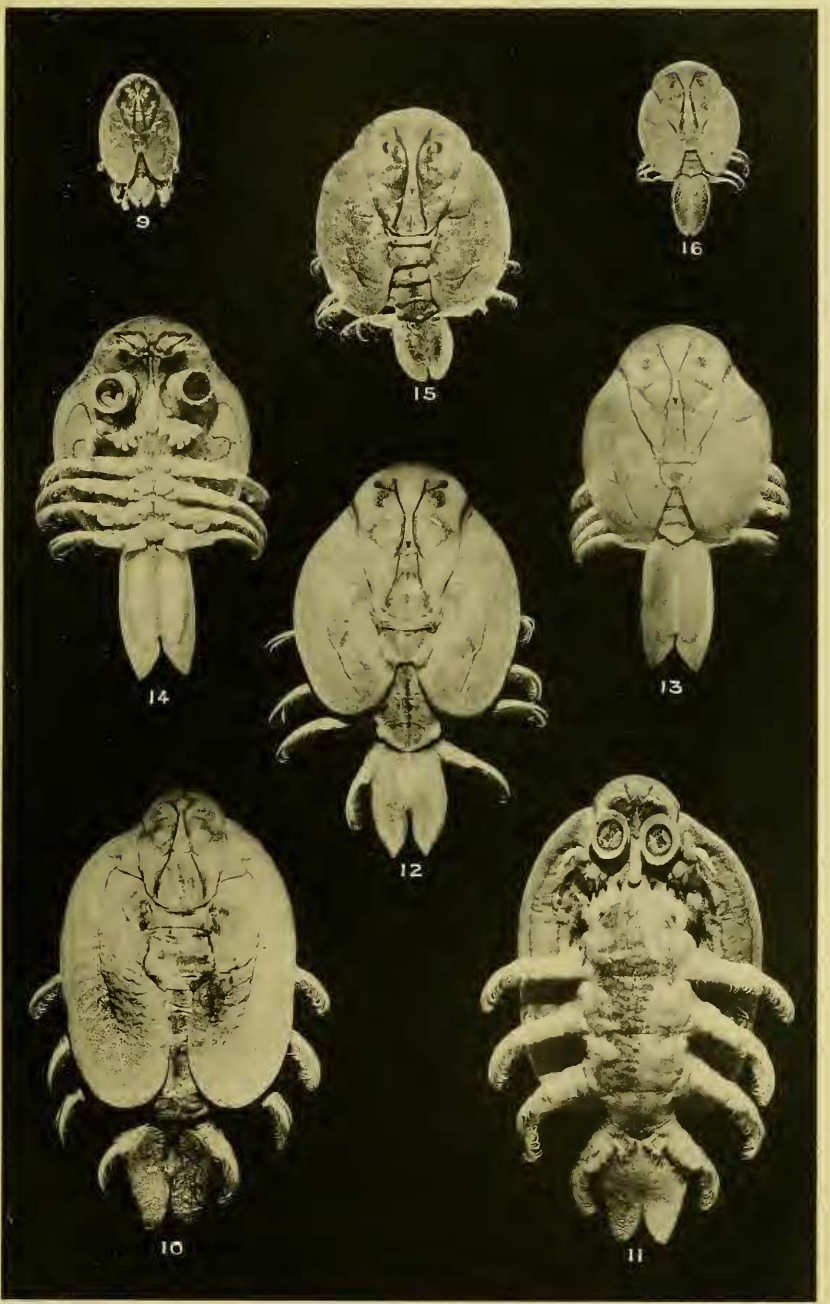
Since the return of the Expedition there have come into my hands specimens of Argulids from Nyasa and from Albert Nyanza; and as these constitute new records and add to our knowledge of distribution, it seems desirable to refer to them also in the present paper. Including the two types collected by Fülleborn in Nyasa, the following is thus a complete list

* For explanation of Plates, see pp. 282–283.



W.A.C. Photo. London Stereoscopic Co. imp.

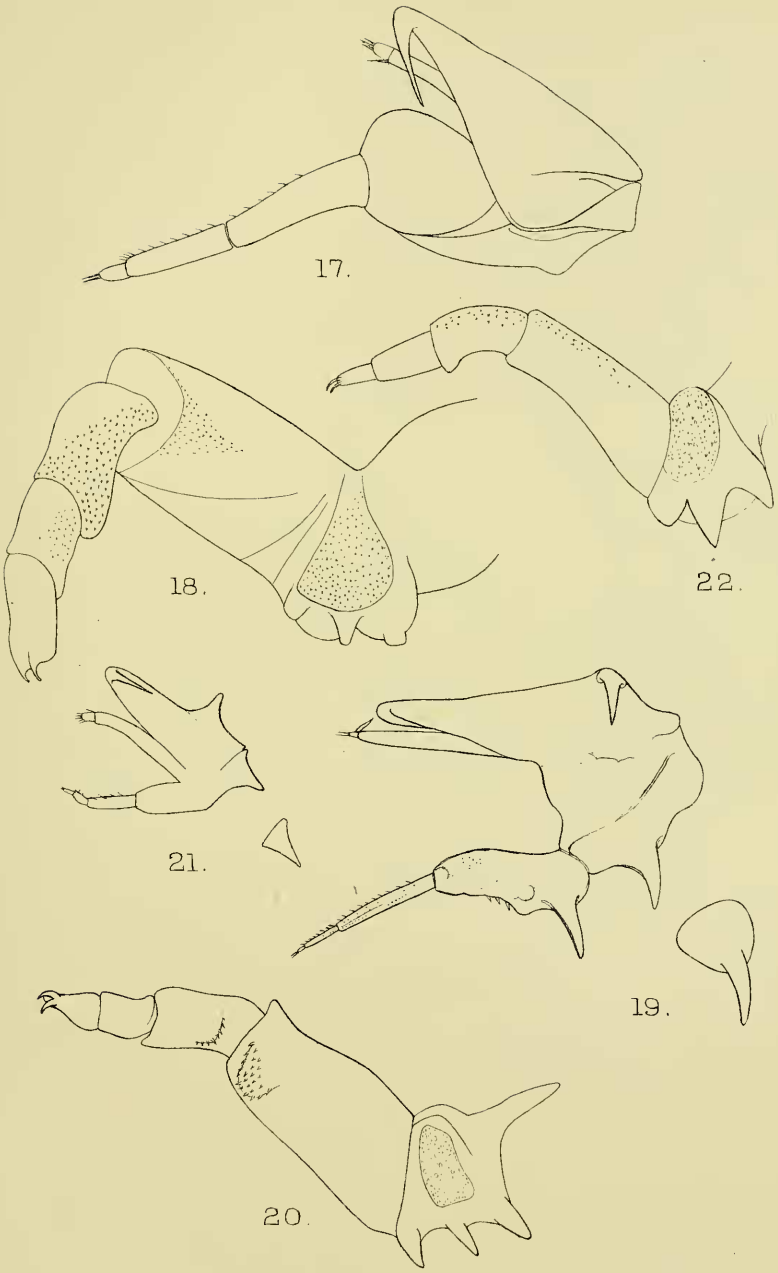
1, 2. ARGULUS INCISUS. 3-5. A. RUBROPUNCTATUS.
6-8. A. PERSONATUS.



W.A.C. Photo. London Stereoscopic Co. imp.

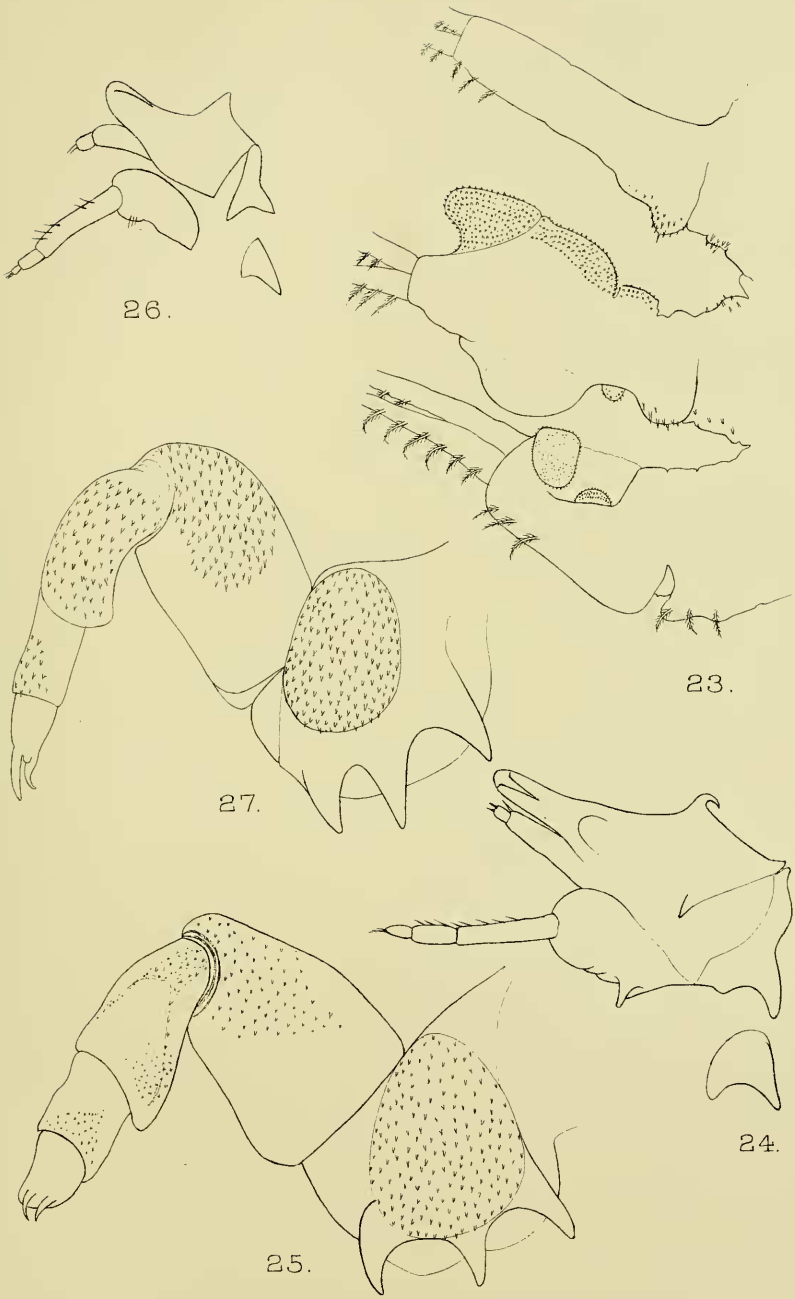
9. ARGULUS EXIGUUS. 10, 11. A. ANGUSTICEPS.

12-14. A. STRIATUS. 15, 16. A. RUBESCENS.



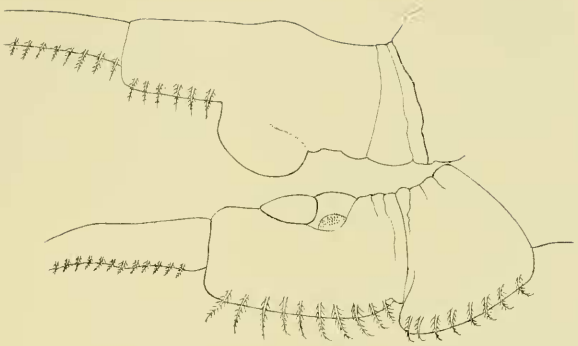
W.A.C. del. Huth sc. et imp

17,18. ARGULUS INCISUS. 19,20. A. RUBROPUNCTATUS.
21,22. A. EXIGUUS.

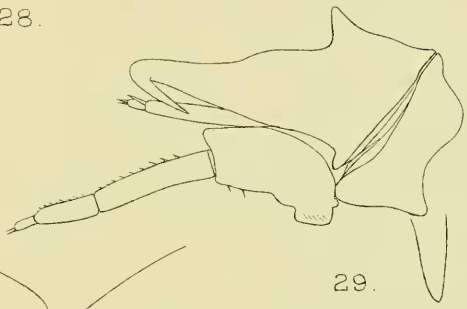


W.A.C. del. Huth sc. et imp.

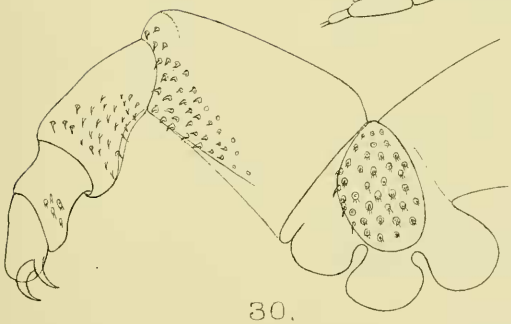
23-25. ARGULUS PERSONATUS. 26,27. A. ANGUSTICEPS.



28.

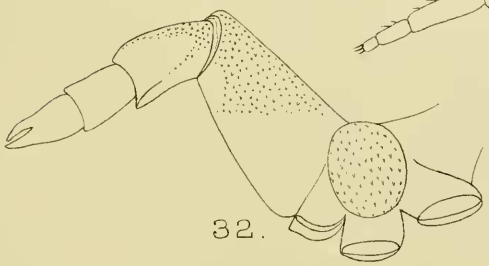


29.



30.

31.



32.

W.A.C. del.

Huth sc et imp.

28-30. ARGULUS STRIATUS. 31,32. A. RUBESCENS.

of the species at present known to occur in the lakes in question :—

Tanganyika.
Dolops ranarum Stuhlmann.
Argulus incisus, sp. n.
,, *rubropunctatus*, sp. n.
,, *personatus*, sp. n.
,, *exiguus*, sp. n.
,, *angusticeps*, sp. n.
,, *striatus*, sp. n.
,, *rubescens*, sp. n.
,, *africanus* Thiele.

Victoria Nyanza.
Dolops ranarum Stuhlmann.
Argulus africanus Thiele.

Nyasa.
Dolops ranarum Stuhlmann.
Argulus africanus Thiele.
Chonopeltis inermis Thiele.

Albert Nyanza.
Argulus africanus Thiele.

By the kindness of Dr. Calman I have been permitted to examine the African specimens belonging to the British Museum. They are of species already known to science, but as, in one instance, they afford a record of a new locality, and as no notice of them has been published, they will be referred to in their place in the systematic part of this paper.

To illustrate the general appearance of the new species, I have made use of photographs taken with a low-power lens from the actual specimens themselves. The difficulties in the way of obtaining reasonably good results from objects which are by no means flat are very considerable, but I think that the photographs in question are really more satisfactory for the purpose than drawings would be. They were made with a special photomicrographic lens in the Zoological Laboratory of King's College, London, and I have to express my indebtedness to Prof. Dendy for allowing me to work in the laboratory, and also to him and to Mr. R. W. H. Row for affording me the benefit of their experience with the apparatus.

2. *Systematic Notes and Description of New Species.*

Family Argulidæ.

Dolops ranarum Stuhlmann.

Gyropeltis ranarum Stuhlmann, Zool. Jahrb., Syst. Bd. vi. 1891, p. 154.

Dolops ranarum Bouvier, Bull. Soc. Philom. sér. 9, tome i. 1899, p. 13.

Dolops ranarum Wilson, Proc. U.S. Nat. Mus. vol. xxv. 1903, p. 737.

Dolops ranarum Thiele, Mitt. Zool. Mus. Berlin, Bd. ii. Heft 4, 1904, p. 17.

This species was originally obtained by Stuhlmann at Bukoba, on the western shores of Victoria Nyanza, and described by him under the name *Gyropeltis ranarum*. The specimens were found attached to the surface, and occasionally at the entrance of the branchial chamber, of a number of tadpoles, and on that account received their specific name. It does not appear a very fortunate title, however, since specimens were obtained by the present Expedition from the bodies of four different kinds of fish, and most of the specimens, as a curious coincidence, actually from Bukoba itself. It is, indeed, no new fact that certain species of Argulidæ may be found on a variety of hosts, the well-known European type, *Argulus foliaceus*, being an excellent example, as its host-list also includes frog-tadpoles as well as a number of fish. The literature of the subject contains other cases of similarly inappropriate specific names derived from those of the hosts, and as long ago as 1875 Claus* deprecated this obvious but unsatisfactory manner of naming species.

It may be no more than coincidence, but it is remarkable how often this form was found associated with *Argulus africanus* on a common host.

Tanganyika.—*Dolops ranarum* does not appear to be common in Tanganyika, since it was obtained on only one occasion, and then from a single large fish. The coloration of these specimens differs somewhat from that stated hitherto, and, in fact, to some extent from the Victoria Nyanza specimens in the present collection. The upper surface of both carapace and abdomen is irregularly covered by arborescent pigment-spots of a grey colour, which are most numerous on the carapace lobes. In addition, there is an irregular series of small white spots, scattered without any apparent relation to the grey pigment-spots already mentioned.

Occurrence.—Kala, 18/11/04. From mouth-cavity and gill-bars of large *Lates microlepis* (length 910 mm.). Three male and three female specimens. Associated with them were specimens of *Argulus africanus*.

Victoria Nyanza.—This is the only species of Argulid hitherto known from the lake, and still seems to be the commonest, although specimens of another widely distributed form (*Argulus africanus*) were obtained during this Expedition. The specimens of *D. ranarum* taken in this lake differ slightly in colour from those collected in Tanganyika. They are of a more uniform brown colour, and show little of the arborescent grey spots above

* Zeitschr. f. wiss. Zool. Bd. xxv. 1875, p. 278.

mentioned, though these are faintly indicated in some cases. The white spots are clearly visible.

Occurrence.—Bukoba, 24/4/05. From surface of body, mouth, and gill-chambers of a large Siluroid (? *Bagrus degeni*)—native name, *Nfui*. Ten male and eleven female specimens. A specimen of *Argulus africanus* was associated with these.

Bukoba, 24/4/05. Associated with specimens of *Argulus africanus* from surface of body and inside mouth of large *Protopterus æthiopicus* (length 1040 mm.). Three males and one female.

Bukoba, 24/4/05. From surface of body, mouth, and gill-chamber of large Siluroid (? *Clarias anguillaris*)—native name, *Nshonzi*. Two male and three female specimens. An individual of *Argulus africanus* occurred with these.

A single female specimen in the collection of the British Museum has been more recently obtained from the lake. The particulars recorded are:—"On skin of fish ('*Mălĕ*') ? catfish. Lake Victoria. Collected by G. D. H. Carpenter, 6. xi. 11." This was associated with specimens of *Argulus africanus*.

Nyasa.—I am indebted to my friend Capt. E. L. Rhoades, of the British Naval Service on Lake Nyasa, for a small collection of Argulidæ from this lake. The specimens all proved to belong to this species, and not to either of those obtained by Fülleborn in the lake. They are thus an addition to the number of forms known in Nyasa, and at the same time a record of still wider distribution of the species. There are two male and four female specimens, the only particulars given on the label being:—"Fish-lice, ex. '*Sungwa*': Lake Nyasa, 1908."

River Nile.—In the British Museum collection are six male and ten female specimens from yet another new locality. With them was associated a single female specimen which I place, with some hesitation, under *Argulus africanus*. They were obtained by Mr. L. Loat, who gives the following details:—"Parasites out of the mouth of a large '*Hala*' (*Heterobranchus bidorsalis*), caught at the mouth of Lake No, White Nile, Jan. 30, 1901."

Genus Argulus.

All the remaining Argulids in the collection belong to the genus *Argulus* itself. The number of species included in this genus is fairly considerable, yet they are, on the whole, reasonably distinct, and there seems to be no grounds for subdividing the genus. As the number grows, it becomes at the same time a matter of increasing difficulty to diagnose a species accurately, save at some length, since the differences are often of a minor nature, concerning numerous parts of the external anatomy. These facts render it more than ever difficult to offer to other workers in this field a satisfactory key to the species.

Wilson *, in 1903, made a serious attempt to provide a key to

* Proc. U.S. Nat. Mus. vol. xxv. 1903, p. 701.

the whole of the then known species of *Argulus*, but without achieving a great success. He was unfortunate in choosing for the purpose certain characters which clearly depend upon the state of contraction of the specimen and, in addition, are difficult to distinguish with exactness. It is not easy, for example, to determine how far the swimming-legs are covered by the carapace, as this is influenced by the relative states of contraction, as well as by any chance displacement. Again, while it is easy in extreme cases to point out forms in which the carapace lobes overlap, or do not reach the abdomen, it is virtually impossible to distinguish accurately those with "Carapace lobes just reaching the base of the abdomen." Most keys are open to the objection that they are purely artificial, and Wilson, it is true, fully admits the artificiality in this case. Nevertheless, a key in which in so many cases male and female specimens of the same species are separated under merely arbitrary standards, falls very short of what is to be desired.

It is certainly a matter of great difficulty in this genus to discover characters which satisfactorily lend themselves to the purpose of key-making. Where male and female differ markedly in external shape, as is sometimes the case, it seems perhaps inevitable that the sexes should be artificially separated; but this might be avoided to a greater degree than has been done by Wilson. While objecting to the form of the key above mentioned, we feel that Wilson is to be commended for attempting to tabulate the species; and since he included all the then-known forms, it at first seemed wise to incorporate in his key the seven new species described in this paper. It was on going into the matter with this end in view that the unsatisfactory features already mentioned revealed themselves, and, in addition, certain regrettable inaccuracies* which only added to the difficulties of incorporation. Under these circumstances it was finally decided to prepare a key to include only the African species; and this is the more desirable, since the one species of this genus hitherto known from the continent is now increased to eight.

Before proceeding to give the key and the descriptions of new species, a few words of caution may be offered. The characters employed in diagnosing the forms belonging to this group, while perhaps the most obvious, are in some cases profoundly influenced by artificial contractions and contortions, and in addition by the age of the individual. Proportions of length to breadth are seldom quite constant, size of suckers may vary with degree of expansion, and certain spines and processes may be more

* *Op. cit.* p. 702. On this page, for example, under the heading 6., *A. niger* is said to have an "abdomen narrow, ovate." Under the heading 7., *A. pugettensis* is contrasted with this as having "abdomen wide, elliptical." Actual measurements of both these species are given in the body of the work, and may be written breadth over length as follows:—*niger* $\frac{3{\cdot}25}{4}$, *pugettensis* $\frac{4}{5{\cdot}3}$. Expressing these in the form of percentage of breadth to length, they become:—*niger* 81·2, *pugettensis* 75·4. Thus it is evident that the abdomen of *niger*, described as "narrow," is in reality broader than that of *pugettensis*, described as "wide."

prominent in some individuals than others. An extensive series of measurements undertaken by the writer has shown that, while sizes and proportions may be stated in general terms, a considerable degree of variation is commonly met with, and that young specimens as a rule deviate somewhat from the normal specific characteristics.

Concerning the actual figures given in the specific descriptions, it is to be noted that the proportions are not always precisely those adopted by Wilson. The latter gives the relative length of the abdomen as a fraction of the entire length of the animal *exclusive of the abdomen*. This has seemed to me less satisfactory than to express it as a fraction of the *total* length of the animal. What is wanted is to indicate briefly what proportion of the total length is constituted by the abdomen, and this mode of expression has therefore been chosen in the following descriptions.

Again, in the matter of the suckers it seems likely that Wilson's fractions are not strictly comparable with those given in this paper, although the same plan has been adopted of expressing the size as a proportion of the breadth of the carapace. My earlier sucker measurements were all made on a basis of the over-all diameter contrasted with the carapace breadth. They gave decimal fractions which seemed to vary somewhat erratically, and it was, moreover, most difficult to decide what might be legitimately considered as the edge of the sucker in an average state of expansion. The well-marked chitinous ring to which the membranous border of the sucker is attached seemed to offer a much more definite structure for investigation, the dimensions of which could be clearly observed. A further series of measurements, in which the size of this chitin ring was taken as a standard of comparison, gave results, when expressed in fractions, which were distinctly more uniform; and this method has consequently been adopted for arriving at the figures given in the specific descriptions. The diameter of the suckers and the corresponding decimal fractions are both smaller, of course, than if the over-all dimensions had been taken; and as the figures obtained are smaller, on the whole, than those given by Wilson, it appears highly probable that his are based on the maximum diameter of the suckers.

Key to the African Species of Argulus.

a. Carapace orbicular, about as long as broad.
  b. Antero-lateral depressions very pronounced; no accessory spines or processes behind the antennules and maxillipeds ..... *incisus*.
  b'. Antero-lateral depressions slight; accessory spines present behind the antennules and maxillipeds ..... *rubropunctatus* ♂.
a'. Carapace elliptical, distinctly longer than broad.
  b. Basal segment of maxilliped bearing spines.
    c. Second segment of antennule with anterior hook.
      d. Abdomen long elliptical, lobes bluntly pointed and separated by moderately broad sinus ..... *personatus*.
      d'. Abdomen broadly elliptical, lobes obtusely pointed and separated by broad sinus; carapace with characteristic reddish spots ..... *rubropunctatus* ♀.

c'. Second segment of antennule with anterior spine.
d. Abdomen slightly longer than broad, sinus less than one-quarter of its length; eyes very large ... *exiguus* ♂.
d'. Abdomen distinctly longer than broad, sinus one-half of its length; eyes and suckers situated close together and far forward ..... *angusticeps* ♀.
b'. Basal segment of maxilliped bearing broad processes.
c. Abdomen long elliptical, at least one and a quarter times as long as broad.
d. Abdominal lobes pointed, sinus one-third or more of length of abdomen; carapace lobes characteristically striated ..... *striatus*.
d'. Abdominal lobes rounded, sinus one-sixteenth of length of abdomen ..... *rubescens* ♂.
c'. Abdomen broadly elliptical, less than one and a quarter times as long as broad.
d. Basal segment of antennule bearing broadly rounded process, second segment with small posterior spiniform process ..... *rubescens* ♀.
d'. Basal segment of antennule bearing somewhat rounded spine, second segment with stout posterior spine; carapace with characteristic black pigment-spots..... *africanus*.

Argulus incisus, sp. n. (Pl. XLI. figs. 1, 2; Pl. XLIII. figs. 17, 18.)

Description.—Carapace orbicular, about as long as broad, with antero-lateral depressions very pronounced, so that portions of the antennæ may be visible from above. Posterior lobes broad and rounded, only covering bases of first and second swimming-legs, and separated by a broad sinus about one-fifth the length of the carapace. The edge of the carapace below is only moderately armed with small spines, which extend to the region of the swimming-legs. There are no such spines in the anterior region in front of the eyes. Abdomen in the male twice as long as broad, about two-fifths * entire length of body; posterior lobes pointed, and separated by broad sinus two-fifths length of abdomen. Abdomen in the female more than one and a half times as long as broad, about one-third entire length of body; posterior lobes bluntly pointed and separated by broad sinus one-half length of abdomen. The furcal appendages in both sexes lie at the bottom of the anal sinus. Antennules and antennæ small and ill-armed, approaching closely to one another in the mid line. The second segment of the antennule only is armed with an inconspicuous anterior spine and slender lateral hook. No accessory spines or processes close behind these appendages. Eyes rather large, in the males less than one-quarter, in the females less than one-fifth breadth of carapace apart, and situated somewhat far forward. Suckers rather large, in the males ·14–·15, in the females ·15† of breadth of carapace. Maxillipeds of moderate size, rather poorly armed; basal segment produced into three flattened processes; "area"

* Proportions not to be confused with those given by Wilson and differently expressed, *vide supra*.

† Diameter of sucker measured at chitinous supporting ring and not at extreme edge.

rather large, roughly pear-shaped and armed with small spines. No accessory processes are present between the bases of the maxillipeds. Flagella present on the first two pairs of swimming-legs. In the male, vesicula seminalis present on the third leg, copulatory peg and accessory cushion on the fourth. In the female, basal segment of fourth leg produced postero-laterally into pointed lobe. Colour (in spirit) light brown, the testes covered above by large irregular blotches of dark brown.

Dimensions as follows :—

Adult male (largest specimen).	mm.	Adult female (largest specimen).	mm.
Total length	7·3	Total length	11·6
Length of carapace ...	4·1	Length of carapace ...	6·2
Breadth of carapace...	4·3	Breadth of carapace...	6·7

Remarks.—The most striking characteristic of this species is the unusually deep antero-lateral depression or sinus, which gives occasion for the specific name. This feature does not occur in any other of the African species—a fact which naturally suggests that excessive shrinkage might be the sole cause. Such an explanation is obviously impossible in this case. The specimens were all of them taken from a single fish, in association with *A. striatus*, but the species were not distinguished on the spot, and all the specimens were treated alike and were brought home in the same bottle. On examination, the deep antero-lateral incision first afforded a palpable distinction between the forms, which proved to be specifically different to a marked degree. Another important feature in which this type differs from the other African species, and indeed from the great majority of the known species, is the complete absence of accessory spines or processes behind both the antennules and maxillipeds.

Occurrence.—Rumonge, 16/2/05. From mouth and surface of body of large specimen of *Auchenoglanis occidentalis*, var. *tanganicanus*. Ten males and thirteen females, some ovigerous. These were associated with a large number of specimens of *Argulus striatus*.

Argulus rubropunctatus, sp. n. (Pl. XLI. figs. 3–5; Pl. XLIII. figs. 19, 20.)

Description.—Carapace in the male orbicular, slightly broader than long; in the female elliptical, slightly longer than broad. Antero-lateral depressions slight. Posterior lobes broad and rounded, covering bases of all but fourth swimming-legs, and separated by a broad sinus about one-fifth the length of the carapace. The edge of the carapace below is well armed with small spines, which extend into the region of the swimming-legs. Abdomen in the male nearly two and a half times as long as broad, about three-sevenths entire length of body; posterior

lobes pointed and separated by fairly broad sinus one-half length of abdomen. Abdomen in the female as long as or slightly longer than broad, less than one-fourth entire length of body; posterior lobes obtusely pointed and separated by broad sinus almost one-half length of abdomen. The furcal appendages in both sexes lie at the bottom of the anal sinus. Antennules of moderate size, basal segment with stout posterior spine; second segment with stout anterior hook and rather slender lateral hook. Antennæ with stout spine on basal segment. Immediately behind the insertion of the antennule is situated a stout accessory spine. Eyes somewhat small, about one-quarter breadth of carapace apart. Suckers in the males rather small, ·12–·14 of breadth of carapace; in the females rather large, ·15–·16 of breadth of carapace. Maxillipeds fairly strong and moderately armed; basal segment produced into three stout spines; "area" of moderate size, oval shape, distinguished by red-brown pigment, but only sparsely armed with spines. A pair of stout accessory spines is situated between the bases of the maxillipeds, and a second pair a short distance behind them. Flagella present on the first two pairs of swimming-legs. In the male, vesicula seminalis present on the third leg, copulatory peg and accessory cushion on the fourth. In the female, basal segment of fourth leg produced postero-laterally into sharply pointed lobe. Colour (in spirit) light brownish grey, covered by an irregular series of red-brown spots, which in part are aggregated together to form definite blotches. Testes covered by irregular blotches of the same pigment.

Dimensions as follows :—

Adult male (largest specimen).	mm.	Adult female (largest specimen).	mm.
Total length	12·2	Total length	10·6
Length of carapace ...	7·1	Length of carapace ...	8·1
Breadth of carapace...	7·7	Breadth of carapace...	7·4

Remarks.—This species affords a good example of the striking differences in form of male and female specimens which are not uncommon, although extremely inconvenient for incorporation in any key. Both the shape and dimensions of the carapace, as well as the nature of the abdomen, are markedly dissimilar in the two sexes. While the red spots and blotches are certainly characteristic of the species, it must be admitted that they are not equally obvious on all specimens. They show little on certain specimens in the collection, which are uniformly of a darker brown colour, and they are less conspicuous on young individuals. The posterior lobes of the carapace, especially in the female, may sometimes nearly meet in the middle line, thus, of course, altering the shape of the sinus and also covering the bases of the fourth swimming-legs.

Occurrence.—Kibwesi, 19/12/04. From surface of head (one

specimen on eyeball) of very large *Lates microlepis* (length 1340 mm.). Thirteen male and five female specimens.

Maswa, 15/1/05. Mostly from the surface of the body of a number of *Lates microlepis*. Fifteen males, seven females.

Ndanvie, 8/2/05. From surface of head and body of large specimen of *Lates microlepis*. Seventeen males, three females.

As will be seen from the above, this form has always been found infesting specimens of *Lates*, and never in association with any other species of Argulid.

ARGULUS PERSONATUS, sp. n. (Pl. XLI. figs. 6–8; Pl. XLIV. figs. 23–25.)

Description.—Carapace elliptical, longer than broad, with rather pronounced antero-lateral depressions. Posterior lobes broad and rounded, covering bases of all but fourth swimming-legs: in a female distended with eggs the third swimming-legs are only partially covered. The lobes are separated by a moderately broad sinus, about one-fifth the length of the carapace or sometimes more. The edge of the carapace below is well armed with very small spines, which extend to the region of the swimming-legs. Abdomen in the male two and a half times as long as broad, about two-fifths entire length of body; posterior lobes bluntly pointed and separated by moderately broad sinus two-fifths length of abdomen. Abdomen in the female about one and a quarter times as long as broad, more than one-quarter entire length of body; posterior lobes bluntly pointed, and separated by moderately broad sinus more than one-half length of abdomen. The furcal appendages are small and inconspicuous and lie at the bottom of the anal sinus. Antennules of moderate size, basal segment with stout posterior spine; second segment with small anterior hook, posterior spiniform process, and lateral hook of medium size. Antennæ with small spine on basal segment. Immediately behind the insertion of the antennule is situated a stout accessory spine. Eyes rather large, about one-quarter breadth of carapace apart. Suckers of moderate size, in the males ·13–·15, in the females ·10–·18 of breadth of carapace. Maxillipeds strong and well armed; basal segment produced into three stout spines; "area" large, pear-shaped, and armed with small spines. A pair of stout accessory spines is situated between the bases of the maxillipeds, and a second pair, rather slighter, a short distance behind them. Flagella present on the first two pairs of swimming-legs. In the male, vesicula seminalis present on the third leg, copulatory peg and accessory cushion on the fourth. In addition, a small backwardly directed process is present near the base of the second leg, and a considerable conical projection on the anterior face of the third leg. In the female, basal segment of fourth leg produced postero-laterally into pointed lobe. Colour (in spirit) light yellowish brown, the testes covered by irregular blotches of darker brown.

Dimensions as follows :—

Adult male (largest specimen).	mm.	Adult female (largest specimen).	mm.
Total length	6·6	Total length	11·4
Length of carapace ...	3·8	Length of carapace ...	7·0
Breadth of carapace...	3·4	Breadth of carapace...	6·0

Remarks.—While exhibiting no very outstanding characteristics, this species is sufficiently well defined by a number of minor differences affecting several parts of its external anatomy. There are only a few specimens in the collection, and, as is usual, the small ones differ to a certain degree from the large. In the smaller specimens the antero-lateral depressions are less pronounced, and the anterior hook on the antennules is less marked or even absent.

In default of a name more obviously suggested by its anatomy, the mask-like appearance of the carapace is alluded to in its specific name.

Occurrence.—Ndanvie, 7/2/05. From mouth-cavity of several specimens of *Bathybates ferox*. Three males, two females.

Argulus exiguus, sp. n. (Pl. XLII. fig. 9; Pl. XLIII. figs. 21, 22.)

Description.—Carapace (in the male) elliptical, considerably longer than broad, with slight antero-lateral depressions. Posterior lobes moderately broad, rounded, covering bases of all swimming-legs, and separated by moderately broad sinus one-third the length of the carapace. The edge of the carapace below is armed with small spines which extend to the region of the swimming-legs. Abdomen in the male slightly longer than broad, about one-quarter entire length of body; posterior lobes bluntly pointed and separated by moderately broad sinus almost one-quarter length of abdomen. The furcal appendages lie at the bottom of the anal sinus. Antennules and antennæ rather small, but moderately armed, approaching somewhat to one another in the mid line. Basal segment of the antennule with posterior spine; second segment with blunt anterior spine, posterior spiniform process, and slender lateral hook. Antennæ with slight spiniform projection on basal segment. Immediately behind the insertion of the antennule is situated a stout accessory spine. Eyes very large, a little more than one-quarter breadth of carapace apart and somewhat far forward. Suckers of moderate size, ·13–·15 of breadth of carapace. Maxillipeds strong and well armed; basal segment produced into three stout spines; "area" of fair size, roughly oval, and armed with small spines. A pair of stout accessory spines is situated between the bases of the maxillipeds, and a second pair, rather slighter, a short distance behind them. Flagella present on the first two pairs of swimming-legs. In the male, vesicula seminalis present on the third leg, copulatory peg and accessory cushion on the fourth.

Colour (in spirit) a reddish brown; in one specimen, the testes are covered by irregular blotches of a darker colour.

Dimensions as follows:—

Adult male (largest specimen).

	mm.
Total length	2·7
Length of carapace	2·1
Breadth of carapace	1·6

Remarks.—This species is unfortunately only represented by two specimens, both of the male sex. They appear to be adult, however, although they are small, and there seems no reasonable doubt but that they represent a distinct species. The compound eyes are unusually large, and are actually larger in proportion than in the species which has been named *A. megalops*. The swimming-legs in these specimens are so backwardly directed, that the bases of at least the last pair are, strictly speaking, covered by the abdomen and not by the carapace lobes.

Occurrence.—Mpala, 31/12/04. From surface of body of small *Simochromis diagramma*. One male specimen.

Mpala, 31/12/04. From outside body of medium-sized *Haplochilus tanganicanus*. One male.

Argulus angusticeps, sp. n. (Pl. XLII. figs. 10, 11; Pl. XLIV. figs. 26, 27.)

Description.—Carapace (in the female) elliptical, considerably longer than broad, with antero-lateral depressions well marked. Posterior lobes moderately broad, rounded, covering bases of all but fourth swimming-legs, and separated by a somewhat narrow sinus, more than one-third the length of the carapace. The edge of the carapace below is well armed with very small spines which barely extend to the region of the swimming-legs. Abdomen in the female slightly longer than broad, about one-quarter entire length of body; posterior lobes somewhat pointed but with rounded tips, and separated by moderately broad sinus one-half length of abdomen. The furcal appendages, which are very small and inconspicuous, lie at the bottom of the anal sinus. Antennules and antennæ small, but moderately armed, approaching closely to one another in the mid line. Basal segment of the antennule with posterior spine; second segment with stout anterior spine, posterior blunt spiniform process, and slender lateral hook. Antennæ with slight spiniform projection on basal segment. Immediately behind the insertion of the antennule is situated a stout accessory spine. Eyes large, one-sixth breadth of carapace apart, and far forward. Suckers small, ·11 of breadth of carapace. Maxillipeds strong and well armed; basal segment produced into three stout and sharp spines; "area" of fair size, roughly oval, and armed with small spines. Both suckers and maxillipeds are situated unusually far forward. A pair of stout accessory spines is situated between the bases of the maxillipeds, and a

second pair a short distance behind them. Flagella present on the first two pairs of swimming-legs. In the female, basal segment of fourth leg produced posteriorly into pointed lobe. Colour (in spirit) a uniform brown, but somewhat darker in the region of the egg-masses.

Dimensions as follows:—

Adult female (only specimen).

	mm.
Total length	10·7
Length of carapace	7·8
Breadth of carapace	5·6

Remarks.—It is unfortunate that this species has to be described from a single specimen. The latter is, however, an ovigerous female which exhibits a number of distinctive features and cannot be classed with any of the known forms. Prominent characteristics are the narrow head region, rather well marked off, and the large eyes placed close together. The eyes, suckers, and maxillipeds are also situated remarkably far forward. The carapace lobes appear curiously thick and fleshy—an appearance which might possibly be due to shrinkage. The specimen was obtained from an uncommon source, namely, from a basket of small fish, but was attached to none of the latter. Thus, although the specimen may well have been dead, there is no reason for supposing that it was dried up to any extent, and indeed, its general condition seems to preclude such a suggestion.

Occurrence.—Uvira, 5/3/05. Found among a number of small fish of different kinds—at the moment adhering to none. A single female, distended with eggs.

Argulus striatus, sp. n. (Pl. XLII. figs. 12–14; Pl. XLV. figs. 28–30.)

Description.—Carapace elliptical, longer than broad, with slight antero-lateral depressions. Posterior lobes fairly broad and rounded, covering bases of all but fourth swimming-legs; in a female distended with eggs, the third swimming-legs are only partially covered. The lobes are separated by a broad sinus one-fifth the length of the carapace. The edge of the carapace below is armed with small spines, which extend to the region of the swimming-legs. Abdomen in the male nearly twice as long as broad, about two-fifths entire length of body; posterior lobes pointed, and separated by broad sinus one-third length of abdomen. Abdomen in the female about one and a quarter times as long as broad, about one-quarter entire length of body; posterior lobes pointed and separated by broad sinus one-half length of abdomen. The furcal appendages in both sexes lie at the bottom of the anal sinus. Antennules of moderate size, basal segment with blunt posterior process; second segment with stout anterior spine, posterior small spiniform process, and lateral hook of medium size. Antennæ with short blunt process on basal segment.

Immediately behind the insertion of the antennule is situated a stout and moderately sharp accessory spine. Eyes rather large, a little more than one-quarter breadth of carapace apart. Suckers, in the males, rather small, ·12–·14 of breadth of carapace; in the females, rather large, ·14–·18 of breadth of carapace. Maxillipeds strong and moderately well armed; basal segment produced into three broad rounded processes; "area" of fair size, pear-shaped, and armed with small spines. A pair of accessory processes, also broad and rounded, is situated between the bases of the maxillipeds, and a second pair, rather slighter, a short distance behind them. Flagella present on the first two pairs of swimming-legs. In the male, vesicula seminalis present on the third leg, copulatory peg and accessory cushion on the fourth. In the female, basal segment of fourth leg produced postero-laterally into pointed lobe. Colour (in formol) light brownish grey, sometimes with a pronounced reddish tinge, the lateral and posterior regions of the carapace lobes showing a distinct radial striation, most clearly seen by transmitted light. Testes covered above by irregular blotches of brown pigment.

Dimensions as follows:—

Adult male (largest specimen).	mm.	Adult female (largest specimen).	mm.
Total length	10·2	Total length	11·1
Length of carapace ...	6·7	Length of carapace ...	7·5
Breadth of carapace...	6·1	Breadth of carapace...	6·5

Remarks.—It is not unusual among the Argulidæ for the posterior carapace lobes to exhibit some striation, which is due, no doubt, to the branching of what Wilson calls the side-pouches of the stomach. This appearance is, however, so outstanding a feature of these specimens, that *striatus* at once suggested itself as a suitable specific name. From the large number of specimens contained in the collection, this would seem to be the commonest, and perhaps the most widely distributed of the Tanganyika species. There are a few small individuals the sexual characters of which are less obvious, and yet others which must be classed as larval forms and do not show the secondary genital modifications typical of the adult.

Occurrence.—Mbete, 25/9/04. From gill-arches and roof of mouth of large male specimen of *Dinopterus cunningtoni* (length 1020 mm.). Twenty-two males and twenty-five females.

Sumbu, 13/10/04. From gill-arches and roof of mouth of large *Clarias robecchii*. One female, associated with specimens of *A. africanus*.

Vua, 29/10/04. From surface of head and mouth of very large female specimen (length 1550 mm., weight 30·6 kilogr.) of a Siluroid (? *Clarias lazera*)—native name *Muomi*. A single male, associated with specimens of *A. africanus*.

Kasawa, 1/11/04. From mouth and gill-bars of large *Dinopterus cunningtoni*. Three male and two female specimens.

Kibwesi, 19/12/04. From head, mouth, and gill-bars of several large specimens of *Chrysichthys brachynema*. One male and one female, associated with specimens of *A. rubescens*.

Rumonge, 16/2/05. From mouth and surface of body of large *Auchenoglanis occidentalis*, var. *tanganicanus*. Sixty-four males and fifty-six females (some larval) associated with specimens of *A. incisus*.

Argulus rubescens, sp. n. (Pl. XLII. figs. 15, 16 ; Pl. XLV. figs. 31, 32.)

Description.— Carapace elliptical, longer than broad, with moderate antero-lateral depressions. Posterior lobes broad and rounded, covering bases of all but fourth swimming-legs, and separated by a broad sinus, more than one-fifth the length of the carapace. The edge of the carapace below is armed with small spines, which extend to the region of the swimming-legs. Abdomen, in the male, nearly one and a half times as long as broad, about two-fifths entire length of body; posterior lobes rounded and only separated by an insignificant sinus one-sixteenth length of abdomen. Abdomen, in the female, slightly longer than broad, about one-quarter entire length of body; posterior lobes rounded and separated by somewhat narrow sinus almost one-quarter length of abdomen. The furcal appendages in both sexes lie at the bottom of the anal sinus. Antennules of moderate size, basal segment with rounded posterior process; second segment with blunt anterior spine, posterior small spiniform process, and lateral hook of medium size. Antennæ with rounded process on basal segment. Immediately behind the insertion of the antennule is situated an accessory rounded process. Eyes of moderate size, a little more than one-quarter breadth of carapace apart. Suckers, in the males, rather large, ·15 of breadth of carapace; in the females, of moderate size, ·13–·14 of breadth of carapace. Maxillipeds fairly strong and moderately armed; basal segment produced into three broad flattened processes; "area" of fair size, oval shape, and armed with small spines. A pair of accessory flattened processes is situated between the bases of the maxillipeds, and a second pair, rather slighter, a short distance behind them. Flagella present on the first two pairs of swimming-legs. In the male, vesicula seminalis present on the third leg, copulatory peg and accessory cushion on the fourth. In the female, basal segment of fourth leg produced postero-laterally into pointed lobe. Colour (in spirit) reddish, but with lighter areas anteriorly and round the eyes. Testes covered above by irregular blotches of reddish brown.

Dimensions as follows:—

Adult male (largest specimen).	mm.	Adult female (largest specimen).	mm.
Total length	3·5	Total length	5·4
Length of carapace ...	2·3	Length of carapace ...	4·1
Breadth of carapace...	1·9	Breadth of carapace...	3·7

Remarks.—This species, which in some features comes near to the preceding one, may be readily distinguished from it by the rounded nature of the abdominal lobes. The reddish coloration, which is striking in the larger specimens, is less evident or almost entirely absent in smaller ones. All the male specimens in the collection, which are rather small, show little colour, except, of course, the characteristic blotching of the testes. It will be noticed that this form has only been obtained from the Siluroid *Chrysichthys brachynema*, which is itself an endemic species.

Occurrence.—Moliro, 24/10/04. From roof of mouth of fair-sized *Chrysichthys brachynema*. One female.

Kibwesi, 19/12/04. From head, mouth, and gill-bars of several large *Chrysichthys brachynema*. Three males and nine females, associated with specimens of *A. striatus*.

Mrumbi, 27/12/04. From inside mouth and outside body of large *Chrysichthys brachynema*. One male and one female specimen.

ARGULUS AFRICANUS Thiele.

Argulus africanus Thiele, Zool. Anz. vol. xxiii. 1901, p. 47.

Argulus africanus Wilson, Proc. U.S. Nat. Mus. vol. xxv. 1903, p. 727.

Argulus africanus Thiele, Mitt. Zool. Mus. Berlin, Bd. 2, Heft 4, 1904, p. 37.

A preliminary description of this form was given by Thiele in 1901, and was followed by a more complete account with figures in 1904. It is the only species of the genus *Argulus* which had been previously obtained from the continent of Africa, and it still remains the only species known outside the confines of Lake Tanganyika. Thiele speaks of it as a form widely distributed in eastern Africa, and it is now possible to add other localities to those hitherto known.

As I have examined more than 60 specimens from different parts of Africa, perhaps I may add a few remarks in modification of Thiele's detailed description. Between the average male and female specimens there is by no means so clear a contrast as he indicates in the relative proportions of the carapace (cephalothorax). It is a fact, as I have determined by actual measurements, that the carapace of a large female is broader in proportion, and so less closely resembles the male condition, but except in extreme cases of large females contrasted with small males, there is but little difference in this respect between the two sexes.

Again, the carapace lobes in the female are stated to cover the whole of the swimming-legs, leaving but the tips of the last two pairs visible from above. This may, perhaps, be the condition of things in an individual greatly distended with eggs, but is neither normal nor typical. In the great majority of the females in this collection, the tips of all four pairs of swimming-legs project from beneath the carapace, and in a few cases the

bases of the fourth pair of legs are also visible much as in the male.

The proportions of the abdomen are likewise indicated as affording a distinction between the species, yet it appears that, as a rule, the female abdomen is really longer than broad, the measurements agreeing closely with those of the male, though of course the shape is distinctly different in the two cases. While these additional observations slightly modify the account given by Thiele, there can be no reasonable hesitation in identifying the species, which is readily distinguished by the conspicuous pigment spots and the nature of the antennæ and maxillipeds.

Tanganyika.—The species is apparently quite common in this lake, as the collection contains more than thirty specimens obtained from various localities. It does not appear to be confined to one host, and it was in some instances found in association with the endemic species of *Argulus*.

Occurrence.—Sumbu, 13/10/04. From gill-arches and roof of mouth of large specimen of *Clarias robecchii*. Four males and four females. A female of *A. striatus* was associated with these.

Sumbu, 20/10/04. From branchial arches and roof of mouth of two smallish specimens of *Clarias robecchii*. Six males and six females.

Vua, 29/10/04. From surface of head and mouth of very large female specimen (length 1550 mm., weight 30·6 kilogr.) of a Siluroid (? *Clarias lazera*)—native name *Muomi*. Five males and five females, with which a single *A. striatus* was associated.

Kala, 18/11/04. From mouth-cavity and gill-bars of large *Lates microlepis* (length 910 mm.). Two females, associated with specimens of *Dolops ranarum*.

Ndanvie, 8/2/05. From surface of head and body of large *Lates microlepis*. One male. Specimens of *A. rubropunctatus* were associated with this.

Victoria Nyanza.—From this lake, too, specimens of *A. africanus* were obtained by the Expedition for the first time. All of them, as it happens, were collected at Bukoba, on the western shore, the place at which Stuhlmann first discovered *Dolops* [*Gyropeltis*] *ranarum*. Curious to relate they were also associated in every case with specimens of the latter, living with them on a common host.

Occurrence.—Bukoba, 24/4/05. From surface of body, mouth and gill-chambers of a large Siluroid (? *Bagrus degeni*)—native name *Nfui*. One female specimen, associated with a number of *Dolops ranarum*.

Bukoba, 24/4/05. From surface of body and inside mouth of large *Protopterus æthiopicus* (length 1040 mm.). Four males, five females, associated with *Dolops ranarum*.

Bukoba, 24/4/05. From surface of body, mouth, and gill-chamber of large Siluroid (? *Clarias anguillaris*)—native name

Nshonzi. A single female, associated with specimens of *Dolops ranarum*.

In the collection of the British Museum are other specimens which have been subsequently obtained. They were also associated with a *Dolops ranarum*. The label reads:—"On skin of fish ('*Mălĕ*') ?catfish. Lake Victoria. Collected by G. D. H. Carpenter, 6. xi. 11." Five male and fourteen female specimens.

Albert Nyanza.—As the result of a rather unusual occurrence, we now know of the existence of Argulidæ in this lake. In a tow-netting from the lake which was placed in my hands for examination by my friend Dr. R. T. Leiper, Helminthologist to the London School of Tropical Medicine, I found very unexpectedly, a young Argulid. The material was collected by Dr. Leiper in July 1907, when he accompanied the expedition despatched to Uganda by the Egyptian Survey Department, and is of special interest at the present time, being the only collection of plankton as yet made in the lake. The tow-netting was taken at the north end of the lake opposite Magungo. While we know of the free-swimming habit of young Argulids, which would render them liable to be taken in the tow-net, it is certainly very exceptional to capture them in this manner, as is evidenced by their complete absence from the extensive series of tow-nettings made during the Third Tanganyika Expedition. It is thus a very happy accident which gives us this additional record.

I believe the specimen to be a male larval form of *A. africanus*. The blunt rounded spines or processes on antennæ and maxillipeds which are characteristic of the adult, are represented by sharper structures in this individual, but I think there is evidence that this is usual in young specimens.

River Nile.—In the British Museum collection, associated with the specimens of *Dolops* obtained by Mr. Loat, and referred to above, there is a single female which I regard as belonging to this species. There are, it is true, points of difference from a typical specimen, yet in view of its general similarity, and since this form is known to occur in the Nile and is commonly found in association with *Dolops*, it seems desirable to place it here. It was taken from the buccal cavity of a large *Heterobranchus bidorsalis*, caught at the mouth of Lake No, White Nile.

3. *General Remarks.*

With singular uniformity, all the collections made in Tanganyika prove, to a greater or less degree, the unique character of the organisms inhabiting the lake. The Branchiura are no exception to the rule, for, as a result of this Expedition, we now know that while two species are widely distributed in Africa, they are associated in Nyasa with a single endemic form, but in Tanganyika with no less than seven. Thus in this case again, Tanganyika

is shown to possess not only a considerable number of characteristic species, but a much richer fauna than the other great African lakes, with which we may reasonably compare it. In the adjoining table of distribution, these facts are expressed in graphic form.

Table of Distribution.

Name of Species.	Tanganyika.	Victoria Nyanza.	Nyasa.	Albert Nyanza.	Other parts of Africa.
Dolops ranarum	+	+	+	...	+
Argulus incisus	+				
„ *rubropunctatus* ...	+				
„ *personatus*	+				
„ *exiguus*	+				
„ *angusticeps*	+				
„ *striatus*	+				
„ *rubescens*	+				
„ *africanus*	+	+	+	+	+
Chonopeltis inermis	...	...	+		
10 species.	9	2	3	1	2

Taking a general survey of the specimens which have been examined, there are a few points which call for mention. Speaking broadly, there is no great disparity in the numbers of the two sexes in the collection. Only in the case of *Argulus rubropunctatus* was there a marked preponderance of one sex, a total of 45 males accompanying 15 females. There were occasional isolated individuals, but both sexes were usually associated on one host. As a rule, females were larger than males, which seems to be commonly the case.

It is difficult to understand why, in certain species, the relative size of the suckers is different in the sexes. The most striking example is that of *A. striatus*, where a series of measurements gave the following results:—Sucker diameter in males ·12–·14 of breadth of carapace: in females, ·14–·18 of breadth of carapace. Such a degree of variation cannot, in this case, be merely an index of carapace diversity in the sexes—short and broad, for instance, contrasted with long and narrow—since these males and females are very similar in this respect. As a rule, where we have sufficient evidence to go upon, the male appears to have a smaller sucker in proportion than the female.

Concerning the relations of these forms to their hosts, some further observations may be offered. Both in Victoria Nyanza and Tanganyika, the smaller fish appear to be relatively little infested by the parasites. These were most frequently observed upon large fish, and particularly on Siluroids, the scaleless nature of which must render them especially liable to attack. Large

specimens of the Tanganyika Serranid *Lates microlepis* also usually bore some examples attached to the surface of the head or within the mouth-cavity.

It is commonly considered that these parasites do not constitute a menace to the fish on which they prey. This was equally the impression made in the present instance. Cases have been recorded, however, in which it seems clear that an excessive number of Argulids infesting a fish may actually cause the death of their host. What appeared to be a striking instance of this came to my notice during this Expedition, and certainly merits a few words of description. Nearing the north-eastern shore of Tanganyika one afternoon, after a long voyage, a large fish was noticed floating on the surface of the water. My men fetched it on board, and it proved to be a specimen of the "kavungwe" (*Auchenoglanis occidentalis*, var. *tanganicanus*), absolutely covered with Argulidæ. There was literally hardly a spot on the body not infested with the parasites, and in the head region and within the mouth they were positively overlapping and lying on top of one another. Instead of detaching isolated specimens, as had usually to be done, a layer of writhing Argulids could be scraped from most parts of the body. The fish was not only perfectly fresh, but was still feebly making convulsive movements, and one could not resist the conviction that it was succumbing to the fierce attack of such a swarm of parasites. The latter, in this instance, did not all belong to one species. There were specimens of both *Argulus striatus* and *A. incisus*, the last-named species, strange to say, being obtained on this occasion only.

It was no very unusual thing on Tanganyika to discover the bodies of large fish floating far from shore. The crew of my dhow kept a sharp lookout, and made a point of picking them up when possible, as it meant a little addition to their fare, unless the fish were too putrid for even their taste. I never saw Argulidæ under these circumstances, except in the case detailed above, but in no other instance was the fish still living. The suggestion nevertheless occurs, that these also may have been victims of such parasites as appear to have caused the death of the *Auchenoglanis*.

No doubt, as is usually the case, the different types of Argulid are not rigidly confined to one host, though they may have a preference for a particular fish. Thus *Argulus rubropunctatus*, taken on different occasions and in different localities, was obtained only from *Lates microlepis*; similarly, *A. rubescens* was found only on *Chrysichthys brachynema*. On the other hand, *A. striatus*, perhaps the commonest and most widely distributed Tanganyikan form, was obtained from a number of hosts, whilst *A. africanus* and *Dolops ranarum*, owing to their extended distribution, clearly have still larger host-lists.

The question suggests itself—do the Tanganyika endemic species infest endemic fish? Since the number of endemic types

of fish in Tanganyika is so great (some 101 out of 115) it is not surprising that they constitute a majority of the actual hosts. Still there is no reason to suppose that there is any significance in such a connection from what we know of the habits of these parasites, and we find, in fact, an endemic *Argulus* living on a widely distributed host, and widely distributed Argulids (*Dolops ranarum* and *Argulus africanus*) living in Tanganyika on endemic fish.

Not infrequently two species were found living together on a common host. It is remarkable that *Dolops ranarum* was almost invariably found associated with *Argulus africanus*. On the only occasion on which the former was obtained in Tanganyika, it was, as usual, accompanied by individuals of the latter. While one is hardly prepared to say that there is a real significance in this association, it is certainly strange that these two widely distributed forms should appear to range together in the localities from which they come. There is no such constancy in the occurring together of other types. *A. rubropunctatus*, though taken on several different occasions, was always found alone.

The question of distribution within the limits of each lake was hardly likely to prove interesting. Apart from forms obtained on a single occasion, there is no evidence that any of the species are confined to a particular region.

EXPLANATION OF THE PLATES.

Plate XLI.

Fig. 1. *Argulus incisus* (p. 268). Male, dorsal view. × 5½.
2. „ „ Female, dorsal view. × 5½.
3. *Argulus rubropunctatus* (p. 269). Female, dorsal view. × 5½.
4. „ „ Male, dorsal view. × 5.
5. „ „ Male, ventral view. × 5.
6. *Argulus personatus* (p. 271). Male, dorsal view. × 6.
7. „ „ Female, dorsal view. × 4½.
8. „ „ Female, ventral view. × 4½.

Plate XLII.

Fig. 9. *Argulus exiguus* (p. 272). Male, dorsal view. × 6.
10. *Argulus angusticeps* (p. 273). Female, dorsal view. × 5½.
11. „ „ Female, ventral view. × 5½.
12 *Argulus striatus* (p. 274). Female, dorsal view. × 6.
13. „ „ Male, dorsal view. × 6.
14. „ „ Male, ventral view. × 6½.
15. *Argulus rubescens* (p. 276). Female, dorsal view. × 6½.
16. „ „ Male, dorsal view. × 6½.

Plate XLIII.

Fig. 17. *Argulus incisus* (p. 268). Antennule and antenna. × 60.
18. „ „ Maxilliped. × 50.
19. *Argulus rubropunctatus* (p. 269). Antennule and antenna. × 40.
20. „ „ Maxilliped. × 30.
21. *Argulus exiguus* (p. 272). Antennule and antenna. × 100.
22. „ „ Maxilliped. × 100.

PLATE XLIV.

Fig. 23. *Argulus personatus* (p. 271). Posterior three swimming-legs to show accessory copulatory apparatus. × 60.
24. ,, ,, Antennule and antenna. × 60.
25. ,, ,, Maxilliped. × 60.
26. *Argulus angusticeps* (p. 273). Antennule and antenna. × 60.
27. ,, ,, Maxilliped. × 60.

PLATE XLV.

Fig. 28. *Argulus striatus* (p. 274). Posterior two swimming-legs to show accessory copulatory apparatus. × 40.
29. ,, ,, Antennule and antenna. × 60.
30. ,, ,, Maxilliped. × 60.
31. *Argulus rubescens* (p. 276). Antennule and antenna. × 60.
32. ,, ,, Maxilliped. × 60.

22. Notes on Plankton collected across the mouth of the St. Croix River opposite to the Biological Station at St. Andrews, New Brunswick, in July and August 1912.

By ARTHUR WILLEY, M.A., D.Sc., F.R.S., F.Z.S., McGill University, Montreal.

[Received January 8, 1913: Read March 4, 1913.]

(Text-figures 54 & 55.)

INDEX.

The marine Plankton of the Atlantic coast of Canada has been examined qualitatively by Professor Ramsay Wright ("The Plankton of Eastern Nova Scotia Waters," 39th Ann. Rep. Dep. Mar. & Fish.: Further Contributions to Canadian Biology 1902–1905. Ottawa, 1907, pp. 1–19, 7 plates); and the Phytoplankton more particularly by Professor L. W. Bailey ("The Marine and Estuarine Diatoms of the New Brunswick Coasts," Bulletin Nat. Hist. Soc. New Brunswick, No. 28, vol. vi. 1910, pp. 219–239, 2 plates).

The estuarine or tidal Zooplankton off the mouth of the St. Croix river does not seem to have received special attention hitherto. As for the quantitative determination of this tidal plankton, and the systematic tabulation of its periodical fluctuations, an endless field of work is offered to the investigator. Samples taken in a tow-net weighted to a depth of 3–5 fathoms

are often very rich in individuals of Copepoda, Cladocera, Diatoms, and Dinoflagellates. The dominant constituent of the plankton at all times is the Diatom, *Coscinodiscus*, which adheres so tenaciously to the bottom of the watchglasses that it obscures the remaining contents. This Diatom genus, together with *Biddulphia*, is recorded as forming the main part of the Phytoplankton in the brackish water of the Weser river (Ch. Brockmann, 1906; see A. Steuer, 'Planktonkunde,' Leipzig and Berlin, 1910, p. 36).

The character of the water in the tract under survey is defined by the predominance of *Coscinodiscus*, and the value or interest of the records accordingly depends upon this circumstance. Of special note in this regard was the occasional appearance of *Fritillaria borealis* Lohmann, an Arctic Appendicularian associated bionomically with the Copepod, *Calanus finmarchicus*. The *Fritillaria* was always more or less damaged by the force of its impact with the tow-net. The *Calanus* was very rare and always immature; each ramus of the fifth pair of legs was bi-articulate instead of being 3-jointed, as it is typically. H. Lohmann ('Die Appendicularien der Plankton-Exped.' 1896, Taf. viii. f. 6, p. 49) has recorded *F. borealis* also from the Antarctic Ocean, but it is not found in the intervening warm regions. L. W. Williams ("Notes on Marine Copepoda of Rhode Island," Amer. Nat. vol. xl. No. 477, Boston, 1906, pp. 639–660) says that *C. finmarchicus* appeared abundantly in tows taken in Naragansett Bay in January, but was found at no other time. Professor Ramsay Wright (*op. cit.* p. 13) says it was very abundant in the earlier part of the summer at Canso. At St. Andrews I noted its occurrence specifically and singly on July 30th and August 5th; the length was 3 mm.

The characteristic and abundant Calanoids at this time were *Acartia clausi* Giesbrecht, *Tortanus discaudatus* Thompson & Scott, and *Eurytemora herdmani* Thompson & Scott. Of these, *A. clausi* was the most abundant; and this is noteworthy, inasmuch as this species was not found at Woods Hole during July and August 1899, although a related species, *A. tonsa* Dana, was one of the commonest copepods in tow taken from the wharf of the U.S. Fish Commission at that station (W. M. Wheeler, "The free-swimming Copepods of the Woods Hole Region," Bull. U.S. Fish. Comm. vol. xix. pp. 157–192. Washington, 1901). L. W. Williams (*op. cit.* 1906) found *Acartia tonsa* abundant throughout the summer in Charlestown Pond, Rhode Island, where it was the predominant copepod in the tow; he also found *A. clausi* abundant in Naragansett Bay in January and February. Thompson and Scott have recorded *A. clausi* from the Gulf of St. Lawrence. It is often coloured with blue spots in pairs below; and it has a large quivering eye with two lenses.

Tortanus discaudatus is characterised by its dark brown caudal furca with variable and unequal rami, the right larger; often

with the basal lobe of the right outer seta enlarged to form a conspicuous process upon the right ramus. Professor Ramsay Wright found it exceedingly common at Canso from the end of July to the middle of August; he offers an explanation of the asymmetrical tail based upon the mode of attachment of the spermatophore (*op. cit.* p. 14). This is very likely correct, but I cannot confirm the statement that the asymmetry is greater in the female than it is in the male. It was not so in my observations at St. Andrews. The species was originally described from the Gulf of St. Lawrence in 1897 (I. C. Thompson and A. Scott, "Notes on new and other Copepoda in Plankton collected continuously during two traverses of the North Atlantic," Proc. and Trans. Liverpool Biol. Soc. vol. xii. 1898, pp. 71–82, pls. 5–7). It was again described as *Corynura bumpusii* by W. M. Wheeler, from Woods Hole and Vineyard Sound (*op. cit.* 1901). L. W. Williams (*op. cit.* 1906) first suggested the identity of *Corynura bumpusii* with *Tortanus discaudatus*; but he described an allied form, abundant in Naragansett Bay and Charlestown Pond, as a new species, *T. setacaudatus*, differing from *discaudatus*, as it would appear, chiefly in the character of the fifth legs in the female, which carry spines in the former and are without spines in the latter species. The eye of *T. discaudatus* resembles that of *Acartia clausi* and quivers in like manner. It would be worth while to make a biometrical study of its remarkable caudal furca. Length of ♂ 1·75 mm.

Eurytemora herdmani Thompson and Scott, is to be distinguished from allied species of the genus, especially from *E. hirundoides*, by the structure of the fifth legs in the female. Females with ovisac were noted on August 12th; and on the same date, males with the tumefied central part of the right antenna scarlet. L. W. Williams (*op. cit.* 1906) recorded three species from the Rhode Island region: *E. americana*, sp. n., *E. hirundoides*, and *E. herdmani*.

The ebbtide plankton of August 9th was largely composed of *Chætoceras* and *Rhizosolenia*, Tintinnoids, *Synchæta*, *Acartia*, Nauplii, some *Fritillaria borealis*, and the Cladocera: *Evadne* and *Podon*. *Podon* occurred in almost every tow, and often contained mature embryos in the dorsal brood-sac. Professor Ramsay Wright mentions two species of each genus as occurring at Canso (*op. cit.* 1907, p. 13). In the same year, what he claimed to be the first American records of *Evadne nordmanni* Lovén, and *Podon polyphemoides* Leuckart, were made by L. W. Williams ("List of the Rhode Island Copepoda, Phyllopoda, and Ostracoda, with new species of Copepoda." Special Paper, No. 30, 1907. Reprinted from 37th Ann. Rep. of the Commissioners of Inland Fisheries of Rhode Island, pp. 69–79, 3 plates).

Of **Dinoflagellates**, *Peridinium divergens* Ehrb. was sometimes very abundant. In the peripheral part of the cytoplasm there

were numbers of relatively large, bright red bodies with a variable and irregular contour. These bodies were not mentioned in Doflein's treatise on the Protozoa; but were duly described by F. Schütt ('Die Peridineen der Plankton-Expedition,' i. Theil. 27 plates. Kiel und Leipzig, 1895). This author calls the red bodies in *P. divergens*, hygrosomes (p. 84), and attributes their formation to similarly shaped plastids, termed hygroplasts (p. 74). He found that their contents are of a fatty nature, blackening with osmic acid and dissolving in ether (p. 85). It is possible that they may exhibit the property of phosphorescence, though I had no opportunity of testing them for this quality.

L. Plate ("*Pyrodinium bahamense*, n. g., n. sp.," Arch. Protistenk. Bd. vii. 1906; see Steuer, *op. cit.* p. 307) suggested that the phosphorescence of *Pyrodinium* depended upon the oxidation of the numerous oil-drops at the hinder end. Bütschli mentions numerous fat-drops in *Peridinium divergens*, which, according to Pouchet, often form an annular zone parallel with the transverse groove; and this same species has been designated the luminous Peridinium of the Gulf of Trieste.

Brachiolaria, the larva of *Asterias*, appeared in the tow from August 10th, and attracted my particular attention on account of the three papilliferous adhesive processes with a median sessile sucker between them, upon the preoral lobe. This Brachiolaria is virtually identical with that of *Asteracanthion pallidus* (= *Asterias vulgaris* Stimps.) as figured by Alexander Agassiz ('Embryology of the Starfish,' 1864; see Selections from Embryological Monographs compiled by Alexander Agassiz, Walter Faxon, and E. L. Mark. II. Echinodermata. Cambridge, Mass., 1883). Agassiz stated that *A. vulgaris* reproduces only in the third week of August at his more southerly station.

Behind each of the three adhesive processes, which are called "brachiolarian arms," there is a long tentacle-like process which may be referred to as a bipinnarian arm. As the term implies, the ciliated band is continued upon the bipinnarian arms but not upon the adhesive processes. On the other hand, the hydrocœl, which can be traced forwards from its pore-canal, sends a diverticulum into each of the adhesive processes but not into the bipinnarian arms.

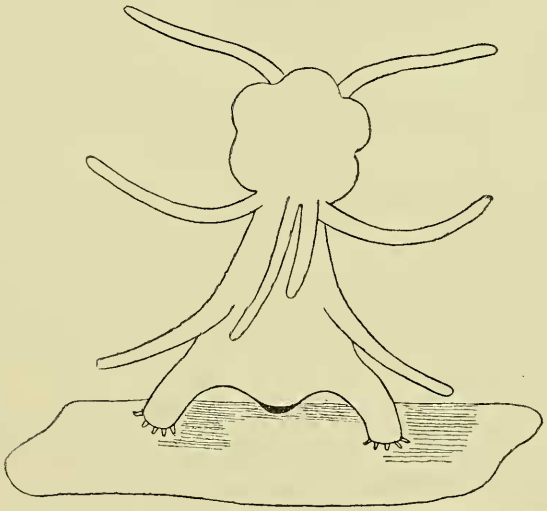
The adhesive processes, or "brachiolarian arms," are structures *sui generis*, but they are paralleled by the three adhesive processes of the Ascidian larva. There is this in common, that they are developed upon the preoral region of the larval body; they serve for the permanent (Ascidian) or temporary (*Asterias*) fixation of the larva, and they consist of one median dorsal process and two lateral processes. It would be hard to find a closer convergence (parallel adaptation) in the category of adhesive organs. Without presuming that they stand for anything more than physiological adaptations, it seems legitimate to infer that some indirect support, by way of analogy, is given to my interpretation of the

anterior lobe which carries them in the Ascidian larva, as a preoral lobe ("Studies on the Protochordata," 1893, Quart. Journ. Micro. Sci. vols. 34 & 35); a suggestion which the late W. K. Brooks was unable to accept.

Apart, however, from questions of morphology, the comparison between the three adhesive processes of Brachiolaria and those of the Ascidian tadpole cannot fail to be appropriate. I am not aware that it has been made before.

Th. Mortensen ('Die Echinodermenlarven der Plankton-Exped.' 1898) figured the Brachiolaria of the European *Asterias rubens*, and adds that it is so much like that of *A. vulgaris* that a separate description is unnecessary; but as the one larva occurs on the North American coasts, and the other on the North European coasts, no confusion is possible. I do not know of any data which would enable a distinction to be made between the larva of *A. vulgaris* and that of the associated species, *A. forbesii*.

Text-fig. 54.



Semidiagrammatic view of Brachiolaria attached to a piece of seaweed.

The larva swims through the water with the three anterior bipinnarian arms curving backwards, the remaining eight bipinnarian arms trailing behind. The anterior medio-dorsal adhesive process is directed forwards; the lateral adhesive processes may be bent forwards or backwards. The median process develops in advance of the lateral processes and is already formed, with its contained branch of the hydrocœl, whilst the lateral processes are represented by rudimentary ectodermal thickenings with a minute projection of the hydrocœl below each of them.

I observed the fixation of the larva to a fragment of red seaweed by means of the adhesive processes, and kept it overnight, alive and attached. The bipinnarian arms became much wrinkled and constricted; the adhesive processes were stretched wide apart so as to allow the median suctorial pad to touch the seaweed between them. The quinque-radiate disc swayed vertically and freely in the water. The accompanying semidiagrammatic sketch (text-fig. 54) will give a better idea of the attached larva than will a verbal description.

A figure from another aspect, after Johannes Müller, of a Brachiolaria fixing itself in a different attitude, is reproduced in the Cambridge Natural History (Vol. i. 1909, Echinodermata, by E. W. MacBride, see p. 613).

I was at first puzzled by the statement in Delage et Hérouard (Traité de Zoologie Concrète, T. iii. Les Échinodermes. Paris, 1903, see pp. 80–81) that the median epithelial pad, between the bases of the brachiolarian arms, is a ciliated sucker (ventouse ciliée,) as I had observed no sign of ciliary action upon it. In a subsequent investigation Delage himself found no indication of ciliation of the median suctorial pad (Yves Delage, "Élevage des larves parthénogénétiques d'*Asterias glacialis*," Arch. zool. expér. sér. 4, ii. 1904, see p. 38).

In larvæ of *Asterias glacialis* raised by Delage from unfertilised eggs treated with carbonic acid, the paired adhesive arms appeared first, towards the middle of the third month of the culture. Brachiolaria which had reached the fourth month in Delage's experiments, showed clearly the initial phenomena of the metamorphosis; they ceased to swim, the bipinnarian arms became shrivelled, and the larvæ adhered by the mobile brachiolarian arms, occasionally shifting their position.

Amongst the numerous larvæ seen by me at St. Andrews, many of which were sketched from life, I only observed the fixation to occur on the part of the oldest, when the asterodisc was most opaque.

The larva does not remain fixed irrevocably at the first spot where it alights upon the bottom; but it never swims again. Therefore it cannot be said that the adhesive arms serve merely for occasional attachment. They represent a definite stereotropic mechanism.

Bolina.—On August 14th at low tide, about 7 A.M., Dr. Huntsman found quantities of *Bolina alata* at the foot of the wharf, adrift in shallow water. I embraced the opportunity thus afforded of making a fugitive study of this remarkable and fragile Ctenophore which defies all methods of preservation.

L. Agassiz ("Contributions to the Natural History of the Acalephæ of North America." Mem. Amer. Acad., Boston, 1849) described the various attitudes of *Bolina*, including one in which the characteristic mantle-lobes are spread out lengthwise, at right angles to the secondary axis in which the tentacles lie, and

parallel with the axis of the mouth and polar sensory field. The two pairs of ciliated auricles are a distinctive feature of *Bolina*. The auricles and the reduced inconspicuous tentacles between them occur on either side of this extended pallial axis. When seen from the aboral aspect, as figured by Agassiz, with the lobes flattened out, the organism exhibits a pronounced biradial symmetry, the mouth-cleft and the polar field being parallel to one another in the direction of the longer axis, which coincides with the plane of the flattened stomodæum, whence it is called the stomodæal axis.

In his memoir on *Pleurobrachia*, Agassiz, in spite of some textual confusion, clearly considered the stomodæal axis to correspond with the sagittal axis of bilateral animals, the tentacular axis with the transverse. Later writers continued the discussion.

Korotneff's genus *Ctenoplana*, which I obtained for the second time in New Guinea waters ("On *Ctenoplana*," Quart. Journ. Micro. Sci. vol. xxxix. 1896), seemed to me at that time to be capable of throwing light on this question. Professor Arnold Lang, of Zürich, had compared the Ctenophore with the Polyclade organization, and I, for one, was penetrated with the conviction that biradial symmetry must have preceded bilateral symmetry. It is now clear that there is no such consecutive necessity; and it appears that the dorsiventrality of *Ctenoplana*, approximating it to the facies of a flatworm, is a very interesting piece of convergence.

The question has been re-opened quite recently by Th. Mortensen ("Ctenophora." Danish Ingolf-Exped., Copenhagen, 1912), apropos of the new sessile Ctenophore, *Tjalfiella tristoma* Mrtsn.

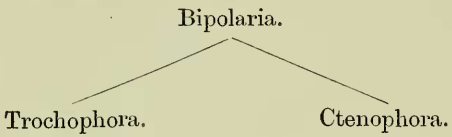
Incidentally Mortensen throws doubt upon the accuracy of my figures of sections showing the peculiar genital ducts of *Ctenoplana korotneffi*; but in so doing he is hardly justified*. I may say, however, that if the morphological comparison between the secondary axes of Radiata (*s. str.*) and the principal axes of Bilateralia were not fallacious, then the relations exhibited by *Bolina* would point to the opposite identification to that which I advocated on the basis of *Ctenoplana* (tentacles in the sagittal plane), but to that which Agassiz advanced on the basis of *Pleurobrachia* (tentacles in the transverse plane).

R. Woltereck ("Wurmkopf, Wurmrumpf, und Trochophora,"

* In *Ctenoplana korotneffi* there were four testes only, in two pairs, paired about the tentacle axis. In one individual there were twelve ducts distributed equally among the four testes. Of these ducts I observed the actual opening to the exterior in six instances, in section. In another individual seven ducts altogether were counted in a series of sections.

With regard to the systematic position of *Ctenoplana*, Abbott says "it must be conceded that *Ctenoplana* stands midway between *Cœloplana* and the Cydippid Ctenophores, in regard to its primitiveness or its degeneracy." And again: "The weight of the morphological evidence bears out the conclusion that *Cœloplana* is a very highly specialized Ctenophore derived from the Cydippida." (James Francis Abbott: "The Morphology of *Cœloplana*," Zool. Jahrb., Anat. xxiv. 1907, pp. 41–70, pls. viii.–x. and 7 text-figures.)

Zool. Anz. xxviii. 1904, pp. 273–322), disposing of excellent data, maintained that the change from a radial to a bilateral form is best understood by the transition from the pelagic to the benthonic habit, on the assumption that Bilateralia are to be derived from pelagic, radiate, marine animals. He reconstructs, in imagination, the ancestral type of Annelids, as a pelagic, spherical, octoradiate, bipolar Cœlenterate, to which he applies the phylogenetic designation: Octoradiata-Bipolaria. His idea of the divergent descent of Ctenophora and Trochophora may be expressed in graphic form:—



Woltereck refers quite simply to *Ctenoplana* as a "creeping Ctenophore." As a creeping Ctenophore its most conspicuous distinctions are a permanent dorsiventrality, the habit of reptation, the presence of pairs of organs, and the possession of a circular mouth. These four qualities are shared by the Polyclade Turbellarians, with bilaterality in addition. Nevertheless, in comparison with the flatworms, these features of *Ctenoplana* are the result of convergence; it is not in the least degree related to the flatworms because of its flatworm habit. To those who have not seen *Ctenoplana* this may have trifling significance; but after seeing it in the living animal, it becomes fraught with meaning, bearing upon the principles and effects of adaptation.

Actinotrocha, the larva of *Phoronis*, appeared in the tow, a solitary example, on August 19th, from about five fathoms. The typical long tentacles were marked with brown pigment; and behind their bases were the small replacing tentacles, indicating that the metamorphosis was at hand. On the preoral lobe or hood, there was a projecting ectodermal knob, a papilla, ciliated and presumably sensory, a little ventral to the apical plate. Such an ectodermal knob on the hood is figured by Marc de Sélys-Longchamps in *Actinotrocha brownei* from Plymouth, England, the larva of an undiscovered *Phoronis*. This larva bears a striking but resemblance to the one at St. Andrews, and I have no doubt but that it is the same species. [M. de Sélys-Longchamps, "*Phoronis*," Fauna u. Flora des Golfes von Neapel, 30th Monograph. Berlin, 1907; see p. 190 and pl. xi. fig. 31.]

In front of the anal peritroch, on the ventral side, was an oblique depression, marking the site of the invagination of the metasome into the interior of the larva.

The eversion of the *Phoronis*-body or metasome took place about 3 P.M. in the watchglass. As I had not expected such a